

Extended Abstract

In a world increasingly conscious of environmental concerns, the management of textile wastewater has emerged as a pivotal challenge. Rapid industrialization and urbanization have propelled the global textile industry to new heights but have led to the generation of vast amounts of wastewater containing synthetic textile dyes. The indiscriminate discharge of textile dyes into our aquatic environment poses a severe threat not only to our environment but also to the very fabric of life that sustains us. The escalating environmental concerns, resource depletion, and health hazards underscore the urgency to address the intricate issues associated with textile wastewater treatment.

The thesis aims to highlight the environmental hazards posed by the textile dyes and assess the effective degradation and detoxification of Brilliant Green and Acid Blue 113 textile dyes from wastewater through the incorporation of bioremediation and integrated techniques. The integrated techniques are the sequential combination of Photocatalytic oxidation and Biodegradation; and biosorption using microbial encapsulation within the Graphene Oxide-Calcium Alginate hydrogel beads, respectively. By addressing these critical implications and offering sustainable solutions, this research aims to contribute to the development of eco-friendly practices in the textile industry.

The implementation of potential microbial consortia demonstrated efficient biodegradation and detoxification of Brilliant Green dye from textile wastewater, showcasing the feasibility of biological approaches in mitigating BG dye pollution. The development of strategies to enhance the biodegradability index of textile wastewater, especially those containing recalcitrant complex dyes (Acid Blue 113), through the implementation of Advanced Oxidation Processes (AOPs) (Photocatalytic Oxidation) as pre-treatment techniques. The design and performance assessment of a hybrid system integrating Photocatalysis and Bioremediation demonstrated its efficacy in achieving efficient AB 113 dye degradation. This integrated approach offers a synergistic solution for enhanced treatment outcomes. The evaluation of

advanced materials, specifically Graphene Oxide-Calcium Alginate-based hydrogels, highlighted their effectiveness for the entrapment of microbes, leading to enhanced complex dye AB113 mineralization. This innovation in material science provides a sustainable avenue for optimizing microbial activities in wastewater treatment. In conclusion, this research significantly contributes to the advancement of dye wastewater treatment methodologies by integrating biological techniques with innovative approaches. The findings underscore the potential of these strategies in achieving efficient, sustainable, and environmentally friendly solutions for the remediation of textile wastewater containing recalcitrant dyes.

This thesis is divided into **7 chapters**. **Chapter 1** embarks on a thorough exploration of the classification of synthetic dyes, their effects on the ecosystem and human health, and a comprehensive elaboration of various textile wastewater remediation techniques. **Chapter 2** ventures into an in-depth review of existing literature, reveals the research gap, and lay the foundation stone for the research objective. **Chapter 3** presents “Biodegradation and detoxification study of triphenylmethane dye (Brilliant Green) in a recirculating packed-bed bioreactor by the bacterial consortium”. In **Chapter 4**, the spotlight shifts to “A comprehensive evaluation of the integrated photocatalytic-fixed bed bioreactor system for the treatment of Acid Blue 113 dye”. As the journey continues, **Chapter 5** delves into “A synergistic approach combining Adsorption and Biodegradation for effective treatment of Acid Blue 113 dye by *Klebsiella grimontii* entrapped Graphene Oxide-Calcium Alginate Hydrogel Beads”. The concluding chapter, **Chapter 6**, summarizes the findings into a cohesive narrative, and recommendations for future research avenues are laid out. In **Chapter 7**, 'Engineering Significance,' the practical applications and broader implications of the research findings are explored, shedding light on their potential impact in real-world engineering scenarios.

The culmination of this thesis is not just the completion of an academic endeavour but also the commencement of a broader journey toward a more sustainable and harmonious

coexistence with our environment. As the curtain rises on this journey, I extend my gratitude to all those who have played a role in shaping this research.